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COMPLEX VISUAL TASK (CVT) SOFTWARE UPGRADE

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ABSTRACT

The purpose of this report is to document the transition of the Complex Visual Task (CVT) from its original format to a computer-based (Windows environment) performance test. We provide initial background information on the test as well as a detailed description of the computerized version. Issues such as navigation through the program and scoring the test are also addressed. Sample input and output files necessary for test administration are included. The report concludes with a brief description of an application of the CVT in an experimental selection test battery for Landing Craft Air Cushion (LCAC) vehicle navigators.

Acknowledgments

We relied on many portions of the original report by LCDR T. Morrison entitled *Complex Visual Information Processing:A Test for Predicting Navy Primary Flight Training Success* (Morrison, 1988). We wish to acknowledge the efforts of Dr. R.J. Wherry in the original development of the Complex Visual Display Task. We gratefully acknowledge the guidance and organization of LCDR P.M. Holmes, Dr. T. Nontasak, and Mr. A. Chapman. We also appreciate the efforts of Dr. D. Blower, Mr. A. Chapman, and LT S. Biggerstaff for their critical review. Special acknowledgment is given to Ms. M. Thomas and ENS B. Williamson for subject testing and database management. We also thank Ms. K. Mayer for her editorial contributions.

INTRODUCTION

The original form of the Complex Visual Task (CVT) was based on a comprehensive task analysis of the component skills needed to extract information from visual displays, tasks underlying the jobs performed by both naval aviators and naval flight officers (NFOs). The CVT was originally designed to accurately reflect the cockpit environment and to measure individual visual information processing capabilities (Morrison, 1988). Specifically, the test assesses an individual's ability to encode verbal information and manipulate pictorial displays in short-term or working memory. These skills are of increasing importance as the array of instrumentation within an aircraft has escalated and become more complex over the years. In fact, Morrison (1988) found that the CVT was predictive of success in Navy primary flight training. Subsequent to the work with aviation personnel, the CVT was adapted by the Naval Aerospace Medical Research Laboratory (NAMRL) for use in an experimental selection test battery for the Landing Craft Air Cushion (LCAC) vehicle navigator crew position. The LCAC training command experienced high attrition rates in its navigator program in the last few years. Task analysis of the LCAC operational environment showed that the navigator position encompasses many of the same skill requirements of the NFO (Hunt, Linville, Stuster, Schneider & Braun, 1993).

Originally, the CVT required an Apple II computer and a 35-mm slide projector. The questions and answers were displayed on an Apple II monitor, with the slides displayed on the adjacent projector. Subjects were instructed to read questions on the monitor, press the *enter* key, and the tactical display would be shown on the projector located to the right of the computer. The newer version of the CVT was developed by NAMRL for any IBM-PC compatible computer running Microsoft® Windows 3.1™ or higher. This Window's version of the CVT eliminates the need for a projector by centralizing the questions, displays, and response feedback on the computer monitor. The upgrade of the CVT has increased both the accessibility as well as the cost-effectiveness of the test. The computerized CVT can be easily distributed on floppy disk and run on a compatible computer.

To port the CVT to an IBM-compatible PC, attributes from each object on a slide were collected to retain the integrity of the original test questions. The attributes recorded included the object's location (i.e., x and y coordinates), angle (45, 90, 180 deg, etc.), shape (triangle, rectangle, pentagon), size (small, medium, large), and color (red, green, white). To collect the x and y coordinates, a transparent graph paper overlay was positioned over the original slide projection to correctly map the inner triangle's point of direction for each object. The additional attributes were recorded for each object from the original CVT slides. As the slide information was coded to a Windows environment, each slide's accuracy was verified by measuring the output of the VGA monitor against the original slide specifications. The objects on the monitor output were continuously readjusted to match their original placement and direction.

CVT TEST DESCRIPTION

The original test is comprised of 120 questions and typically requires 60-90 min to complete. The computerized version of the CVT provides a comprehensive set of instructions incorporating color graphics to provide actual examples and additional clarification. In the instruction section, the subject is informed that triangles represent airplanes, rectangles represent aircraft carriers, and pentagons represent destroyers. The subject must memorize the representations to respond

accurately to several test questions. In terms of test-taking strategies, the subject is instructed to perform the speed and accuracy trade-off by completing the questions "as quickly and as accurately as possible."

Navigating Through the Test

At the onset of the test, the subject is presented with a test question. After reading the question, the subject prompts the tactical display by pressing the *enter* key. The display contains a circle with crosshairs and a number of objects of various shapes, sizes, colors, quadrant location, and direction. The subject is instructed to pay close attention to the objects and their various attributes. The bottom of the display contains instructions and a a field for entering the answer. For example, the subject is reminded to enter '1' for 'true' responses, '2' for 'false' responses, or a number for the quantitative questions. For example: *More than 7 objects are in the right portion of the screen (True or False)?* (Fig. 1). The correct answer is false.

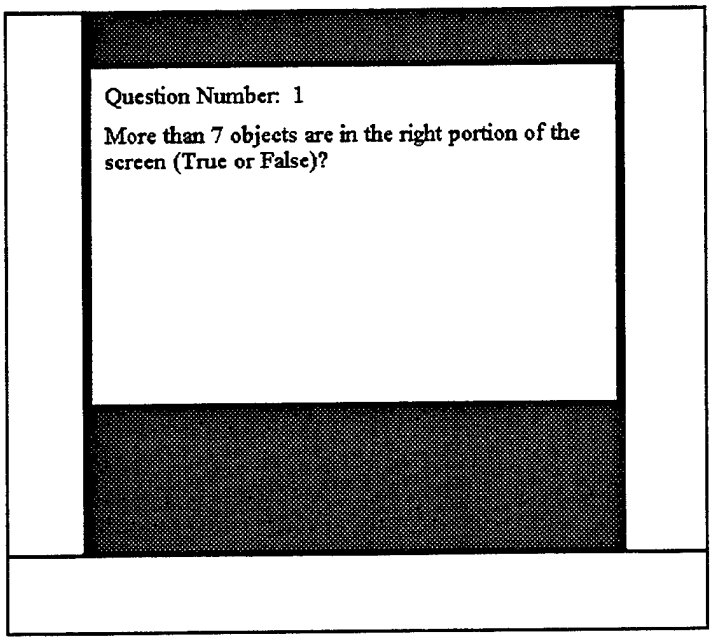

Figure 1. CVT Question Display

The subject is required to encode the quantity and location of the objects on the display in order to respond to the question.

Test questions are arranged in increasing difficulty. The determination of the difficulty is presented in the section detailing the CVT's use in an experimental test battery. An example of a "hard" question is: *No more than 3 medium-sized objects are in the upper portion of the screen outside the circle?* This question requires the subject to recall the quantity of three, the shape, and a particular area of the screen outside the circle. The examinee will press the *enter* key to prompt the tactical display (Fig. 2) .

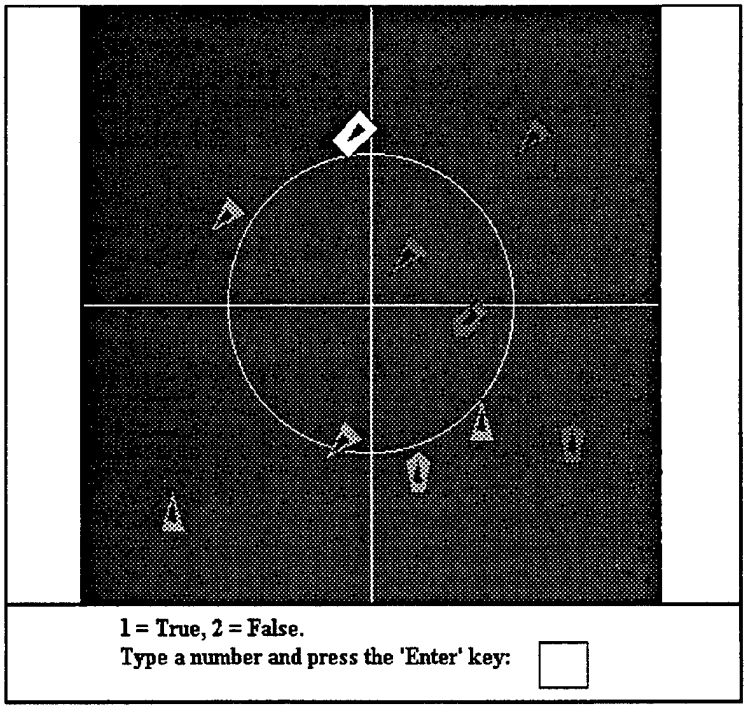

Figure 2. CVT Tactical Display.

When the subject responds, feedback is provided at the bottom of the display. By pressing the *enter* key, the subject prompts the next question.

Scoring the Test

The first test performance measure is question accuracy. We also record two reaction times for each question. The first reaction time, referred to as *question comprehension time*, is the duration between question presentation and the subject's response (i.e., prompting the tactical display). The second reaction time, *answer reaction time*, is the duration between the presentation of the tactical display and the subject's response.

THE OUTPUT FILE

In the first column of the sample output file, Q#, identifies the question number (Table 1). The second column, question time, indicates the question comprehension time in seconds. The third column, answer time, indicates the answer reaction time in seconds. The fourth column contains the subject's actual input. The fifth column contains the correct answer to the test question. The sixth column indicates whether the subject answered the question correctly or

incorrectly. A correct response is coded as a 1, an incorrect response as a zero. The seventh column tallies the number of correct responses and indicates the cumulative score for the entire test. The output files are labeled as an *.out extension.

At the bottom of each test file is a section which summarizes the subject's overall test results. Mean reaction times are individually computed for responses answered correctly and incorrectly, as well as an overall average (Table 2). The total column displays the number of correct, incorrect, and total responses.

Table 1. CVT Sample Output File

Q#	Question Time	Answer Time	Subject's Answer	Correct Answer	Correct Score	Cum Score
1	20.60	6.49	T	T	1	1
2	9.00	5.79	T	F	0	1
3	5.05	9.56	6	7	0	1
4	10.38	7.67	4	4	1	2
5	23.35	11.43	F	T	0	2

	Average Question Time	Average Answer Time	Total
Correct	15.49	7.08	2
Incorrect	12.46	8.93	3
Overall	13.68	8.19	5

THE INPUT FILE

To reiterate, the CVT is composed of tactical displays that depict objects of various attributes. Each slide contains between 12-20 objects. To display each object on the monitor, the data collected on its attributes (shape, size, color, angle, and location) were coded for a Windows environment. The description of the sample input file is described in Fig. 3.

```
CVTT
<QT=F>
<N=1>
<T>
Exactly 5 objects are in the right portion of the screen (True or False)?
</T>
<J 2 2 3 45 -25 97>
<J 1 2 1 45 78 94>
```

```
<J 1 2 2 45 -102 50>
<J 1 2 1 45 5 27>
<J 3 2 1 45 42 -7>
<J 1 2 2 180 59 -42>
<J 1 2 2 45 -34 -77>
<J 3 2 1 180 111 -55>
<J 3 2 2 180 21 -71>
<J 1 2 2 180 -123 -93>
<R>
Exactly 6 fit the description given.
</R>
<A=6>
</Q>
</.>
```

Figure 3. Sample CVT Input File

The first line contains *CVTT*, which is a tag that identifies the file as an input test file. The next line contains the question type tag *<QT=F>* followed by the equal sign indicating the correct response. Other question types include *<QT=T>* used to identify the question as a true/false type question with a correct answer of true, and *<QT=N>*, to identify the question as a quantitative question with a correct numerical answer. The following line *<N=1>* identifies this question as question number 1 in the CVT test. The next three lines contain the question text. The tag, *<T>*, indicates that the beginning of the question text will appear on the subsequent line. Following the question text is the tag *</T>*, which denotes the end of the question text.

The next 10 lines describe the various object attributes, with each line representing one object. Each line begins with *<J*, followed by the object data, followed by > that marks the end of that object's description. On the first line, the object data are shown as *<J 2 2 3 45 -25 97>*. The object data are arranged in the following order: shape, size, color, angle, and x, y coordinates. Each object is one of three possible shapes: triangles, rectangles or pentagons and is represented as the numbers 1, 2, and 3, respectively. Similarly, each object is one of three possible sizes: small, medium, or large, and is indicated as 1, 2, and 3, respectively. Each object is one of three possible colors, red, green, or white, and are indicated as 1, 2, and 3, respectively. The next data point indicates the angle of the object. The most common angles included 0, 45, 90, 180, and 270 deg although adjustments were made to ensure the direction of the object on the monitor was similar to the object on the slide. The angles increase in magnitude in a clockwise manner. The final two items of data indicate the location, or x and y coordinates, of each object based on the location of the point of the inner triangle. For example, *<J 2 2 3 45 -25 97>* indicates that this object is a medium white rectangle with a 45^0 angle at -25, 97 on the tactical display.

The next three lines in the original sample input file describe the feedback text displayed after the subject's response. The tag *<R>* informs the CVT software that the response text will be on the following line, and the tag <\R> indicates the end of the response. In the example, after the subject responds, the text *"Exactly 6 fit the description given"* is displayed. After this line, the tag *<A=6>* indicates that the numerical answer to the question is six. The last line of the example

shows a tag </Q>, indicating the end of question number one. The input file format described in this section continues for each question until an *end of test* tag is located. The *end of test* tag is indicated by <./>.

TEST OPERATION FILES

Administration Section

The following list indicates the files necessary to administer the CVT. Researchers at the NAMRL attempted to adjust the length of the CVT because it will be one of several tests in an experimental test battery. The initial test data collected was based on the first 60 questions and the second 60 questions, which explains the various test files. The process used to select 60 appropriate questions is discussed in a later section. The following description provides an outline of the directory and file setup used to administer the pilot version of the CVT to test subjects.

Contents of \cvt-demo\input

cvt1-60.tml	Input test file that contains questions, answers, and object data for slides 1 - 60.
cvt61-.tml	Input test file that contains questions, answers, and object data for slides 61 - 120.
navig.tml	Input test file that contains questions, answers, and object data for slides selected for experimental test battery.
demo.tml	Input test file that contains questions, answers, and object data for 10 slides used for demonstration purposes.

Contents of \cvt-demo\output

* .out	Any file with an *.out* extension is a subject's test file.

Software Engineer Section

To ensure portability with future versions of the CVT, we recommend using the Borland C++ compiler (version 4.0 or higher).

Contents of \cvt-demo\source C++ language source files

cvt.cpp	Source code for CVT test.
cvt.h	Header file for cvt.cpp.
instruct.cpp	Source code for Instructions section.

instruct.h	Header file for instruct.cpp.
waiter.cpp	Source code for *waiting* between the Administration and Instruction sections.
waiter.h	Header file for waiter.cpp.
admin.cpp	Source code for test file and directory setup.
admin.h	Header file for admin.cpp.
info.cpp	Source code file for Subject Number section.
windows.h	Header file for Windows API calls.
cvt.ide	Project file for CVT (Borland C++ 4.0 compiler).
cvt.rc	Resource file for CVT questions.
cvt-lbl.bmp	CVT introduction label.
pgdown.bmp	*Page down* label for the CVT instructions.
center.bmp	Instruction example showing the center of the circle.
cvtc1.bmp	Tactical display example slide.
cvt-lbl2.bmp	Heading for CVT instructions.
nsew.bmp	Instruction example showing north, south, east, and west on the tactical display.
ultest.bmp	Instruction example showing the upper left section of the tactical display.
urtest.bmp	Instruction example showing the upper right section of the tactical display.
lrtest.bmp	Instruction example showing the lower right section of the tactical display.
lltest.bmp	Instruction example showing the lower left section of the tactical display.
shapes.bmp	Instruction example showing each shape's size and color.
triangle.bmp	Instruction example slide of triangles.
pentagon.bmp	Instruction example slide of pentagons.
rctangle.bmp	Instruction example slide of rectangles.
cvt.ico	Icon for the CVT.

Contents of \cvt-demo\instr

cvtinst.txt	Instruction file for the CVT.

Contents of \cvt-demo\bin

cvt.exe	Executable program for the CVT.

Contents of \windows

cvt.ini	Initialization file that contains the settings for the directories.

MINIMUM HARDWARE CONFIGURATION

386 - 25 MHZ IBM-compatible PC with a minimum of:
- 4 MB RAM memory
- 1.44 MB 3.5" floppy disk drive
- 20-MB hard disk drive
- VGA video card
- 15" VGA compatible color monitor

Uninterruptable Power Supply
Numerikeys Keypad System

APPLICATION OF THE COMPUTERIZED CVT

Morrison (1988) demonstrated the predictive validity of the CVT in the selection of naval aviators and NFOs. Due to the similar nature of the task demands, the researchers at the NAMRL incorporated the computerized version of the CVT into an experimental test battery to be used in the selection of Landing Craft Air Cushion (LCAC) vehicle navigators. For purposes of a subtest in the experimental test battery, the length of the CVT was decreased from the original 120 to 60 questions.

To select the appropriate test question bank, performance data were collected from 67 aviators and flight officers. The data were analyzed by determining the level of difficulty of each question independently. The criteria for the level of difficulty were based on the percentage of the sample with the correct answer in relation to both of the reaction times. The test items were classified as easy, medium, or difficult. Fifteen 'easy' questions, 30 'medium' questions, and 15 'difficult' questions were chosen for the shorter version of the test. The revised test requires approximately 30-45 min to complete and was incorporated into the LCAC Navigator Selection System. The system, which includes the CVT and other computer-based tests developed at NAMRL (Chapman & Nontasak, 1996, in press; Helton, Nontasak, & Dolgin, 1992; Dolgin, Street, Nontasak, Blower, & Travis,1992) is currently being used operationally to test LCAC Navigator candidates at NAMRL and provide assignment recommendations to the Bureau of Naval Personnel.

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13. ABSTRACT *(Maximum 200 words)*
The purpose of this special report is to provide a brief description of the transition of the original Complex Visual Task (CVT) test format to a computer-based (Windows environment) performance test. The results of previous research indicate that the CVT may be related to success in Navy primary flight training. The test is intended to assess an individual's capability to encode verbal information and manipulate pictorial displays in short-term or working memory. As the array of instrumentation within an aircraft increases and becomes more complex, assessment of these necessary skills becomes critical. The CVT was adapted by the Naval Aerospace Medical Research Laboratory (NAMRL) for use in an experimental selection test battery for the position of Landing Craft Air Cushion (LCAC) navigator since this position encompasses many of the same skill requirements of the Naval Flight Officer.

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